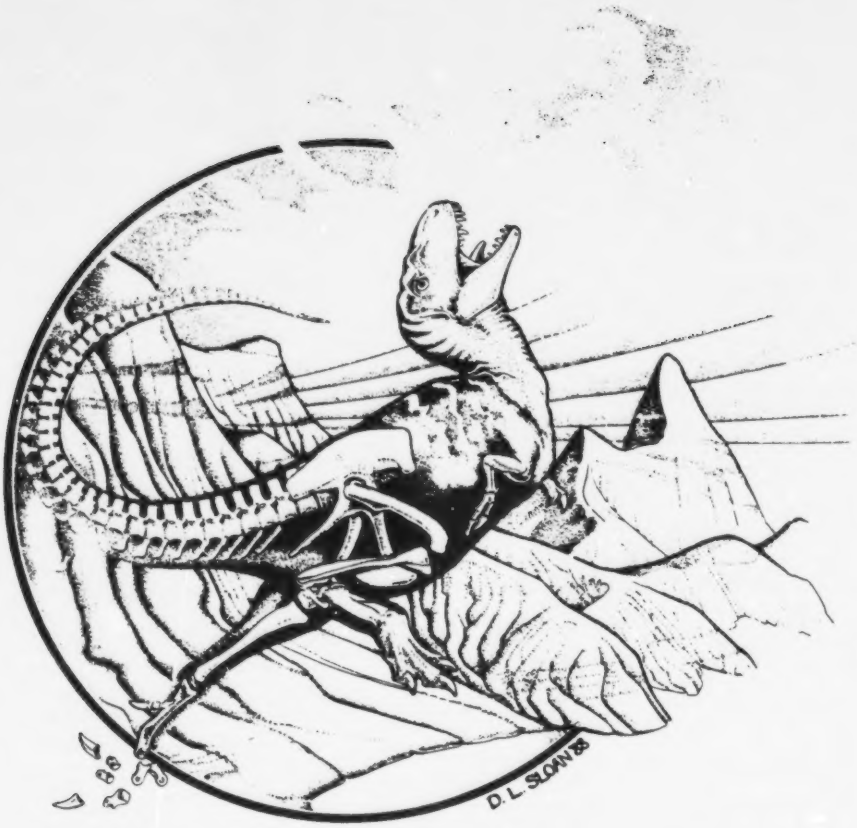


Society of Vertebrate Paleontology

48th Annual Meeting

FIELD TRIP "D" (October 16, 1988)

STRATIGRAPHY AND PALAEONTOLOGY OF THE HAND HILLS REGION

by

James A. Burns and Robert R. Young

OCCASIONAL PAPER OF THE TYRRELL MUSEUM OF PALAEONTOLOGY, #9

1988

Tyrrell Museum of Palaeontology

Alberta
CULTURE AND MULTICULTURALISM

Society of Vertebrate Paleontology
48th Annual Meeting

FIELD TRIP "D" (October 16, 1988)

STRATIGRAPHY AND PALAEONTOLOGY OF THE HAND HILLS REGION

by

James A. Burns and Robert R. Young

OCCASIONAL PAPER OF THE TYRRELL MUSEUM OF PALAEONTOLOGY, #9

© 1988

Additional copies of this volume can be ordered from:
Tyrrell Museum of Palaeontology
Box 7500
Drumheller, Alberta, Canada
T0J 0Y0

ISBN 1-55006-111-9
Cover illustration by Donna Sloan

Stratigraphy and Paleontology of the Hand Hills Region, Alberta

James A. Burns, Quaternary Paleontology, Provincial Museum of Alberta
Robert R. Young, Department of Geography, University of Alberta

INTRODUCTION

Alberta's fame as a treasure-trove of vertebrate fossils is based on the richness of its Cretaceous dinosaur remains. Knowledge of their existence in the badlands of the Red Deer River Valley, southern Alberta dates back more than a century.

Apart from the Cretaceous representation are a number of Tertiary deposits in the province (Storer 1978). Middle-to-late Tertiary deposits are most frequently found as gravels which cap relict uplands. Most notable of these Tertiary units are the Cypress Hills of southeastern Alberta and southwestern Saskatchewan. These have yielded lower Oligocene and middle Miocene fossils. Among the remaining uplands, the Hand Hills near Drumheller are becoming increasingly significant with respect to the late Tertiary and Quaternary paleontology and stratigraphy of the area. Early attempts at correlation equated the upper gravels in the Hand Hills with the Oligocene Cypress Hills gravels, but Warren (1939) showed them to be correlative with the gravels of the Flaxville Plain of eastern Montana. The gravels are thought to have been deposited during the latest orogeny of the Rocky Mountains to the west. Storer (1972, 1976) confirmed this with fossil recoveries. We now know that the Hand Hills have strata representing the later portions of each of the Cretaceous, Paleocene, Miocene, and Pleistocene.

The Hand Hills have been subject to a number of scientific investigations (Stalker 1973). The first appears to have been that of Dr. James Hector, geologist to the Palliser Expedition of 1857-1860 which was sent to survey the western territories of British North America. Hector (1861) reported invertebrate fossils, particularly oysters and the straight ammonite, *Baculites compressus*, discovered during a campover at the base of the Hand Hills in 1858 or 1859. Later studies in the Hand Hills (M^{c}Connell 1885; Tyrrell 1887; Warren 1939; Allan and Sanderson 1945; Stalker 1973) addressed bedrock, economic geology and surficial geology in terms of correlation and glacial history.

Dinosaur bone occurs in the Hills but only as unidentifiable, redeposited fragments dredged up by glacial action. So, it was not until 1958 that a fossil was reported from the Hand Hills. This was a horse astragalus found at Mother's Mountain and attributed to the late Pliocene or early Pleistocene by Russell (1958). Storer (1972, 1975, 1976) was next to report paleontological materials from the Hand Hills. He described middle Miocene and Pleistocene specimens from what is now known as the Sinclair site. He identified (1975) the first Hand Hills prairie dog specimen (as *Cynomys ludovicianus*). Glacial deposits here were judged to be continuous with the underlying gravels because a definite contact between the units was not observed. The fossils appeared to be mixed in the transitional stratum.

Prairie dog fossils were rediscovered by Tyrrell Museum personnel in 1983. Because the fossils were

suspected to be Pleistocene, the site was referred to JAB. In the next three years our efforts focussed on the excavation of fossil burrows at the Winter Site which yielded over 3000 bone and tooth specimens mostly attributable to a new species of *Cynomys* (Burns and McGillivray, in prep.). An AMS radiocarbon age of 22,200 ± 320 y B.P. on *in situ* prairie dog bone from the Winter Site provided a temporal datum. The collected information, not anticipated in the literature, bears on burrow architecture and broadens our understanding of the Late Wisconsinan zoogeography of *Cynomys* in Alberta. During the last three years curiosity about the taphonomy of the prairie dogs has channelled RRY's interests into reconstructing the glacial history of the area His findings challenge some orthodoxies. One real bonus has accrued from two sites which gave up identifiable Miocene fossils and so assisted with stratigraphic correlations. The field trip, then, will take you on a whirlwind tour into the world of paleontology and geology in the Hand Hills and demonstrate their essential interdependency. A summary of stratigraphy will be given at the end of this guide.

THE ITINERARY

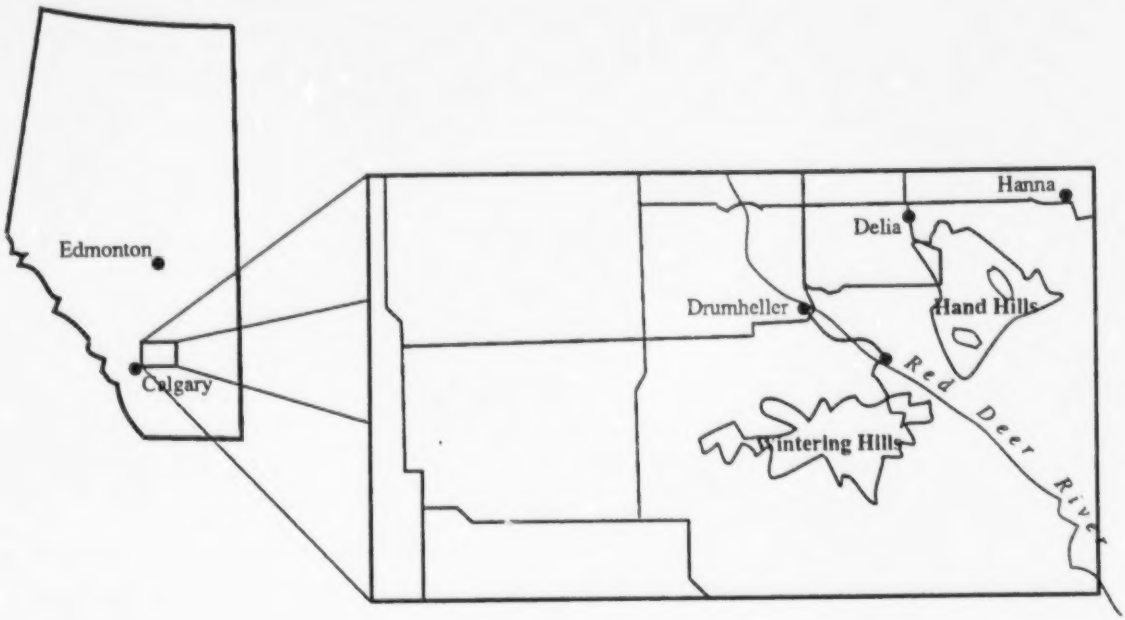
The tour leaves the Tyrrell Museum and Drumheller behind in the valley of the Red Deer River (Figure 1). It should be remembered that this valley, and indeed, river valleys throughout most of Alberta, are erosional products of the postglacial period, roughly the last 12-14 thousand years (Dyke and Prest 1987). As we drive north on Highway 9 you will note a steep ascent as we approach the valley rim. Geologically we are passing up through sediments of the middle one-third of the **Horseshoe Canyon Fm** (Late Cretaceous) which is composed of freshwater facies that contain some fossil material (Figure 2). The Cretaceous sediments are capped by **Glacial Lake Drumheller** sediments formed by ponding in the wake of the northeasterly-retreating late Wisconsinan ice sheet. Once attained, the "bald prairie" spreads out before us. The high agricultural productivity of this region is due to the underlying glaciolacustrine sediments which perch both water and nutrients. Most highly productive farm lands in Alberta are similarly located in former glaciolacustrine basins.

About 15 km north you will be able to see the Hand Hills on the **right** (east). The highest point is at about the centre of the profile and rises to about 1090 m (3575 ft) a.s.l. The name "Hand Hills" has several suggested etymological origins. A colourful version suggests that, during a skirmish between warring Indian tribes, one chief lost a hand. In fact, the Hills used to be called the Michichi Hills. "Michichi" is the Blackfoot Indian word meaning "Little Hand." A chief of that name is known to have lived and died (in grisly fashion) in this area and is the namesake.

We will approach the Hills from the north in the general direction of the most recent glaciation. From Highway 9 we turn south onto S.R. 851. After a few wiggles south of the sleepy town of Delia you will see a distinct escarpment ahead that forms the northern margin of the Hills. It is thought that the late Wisconsinan glacier "drumlinized" the Hills, leaving a blunt stoss side.

STOP 1 : At the base of the Hills, on the **right**, is a road cut that features **Horseshoe Canyon Fm.** Coal was mined here during the Depression years. Localized pockets of diamict are found on the lower slopes of the Hills but have not been studied as they are probably the result of Holocene colluviation.

Figure 1; Regional and local maps of field trip area.



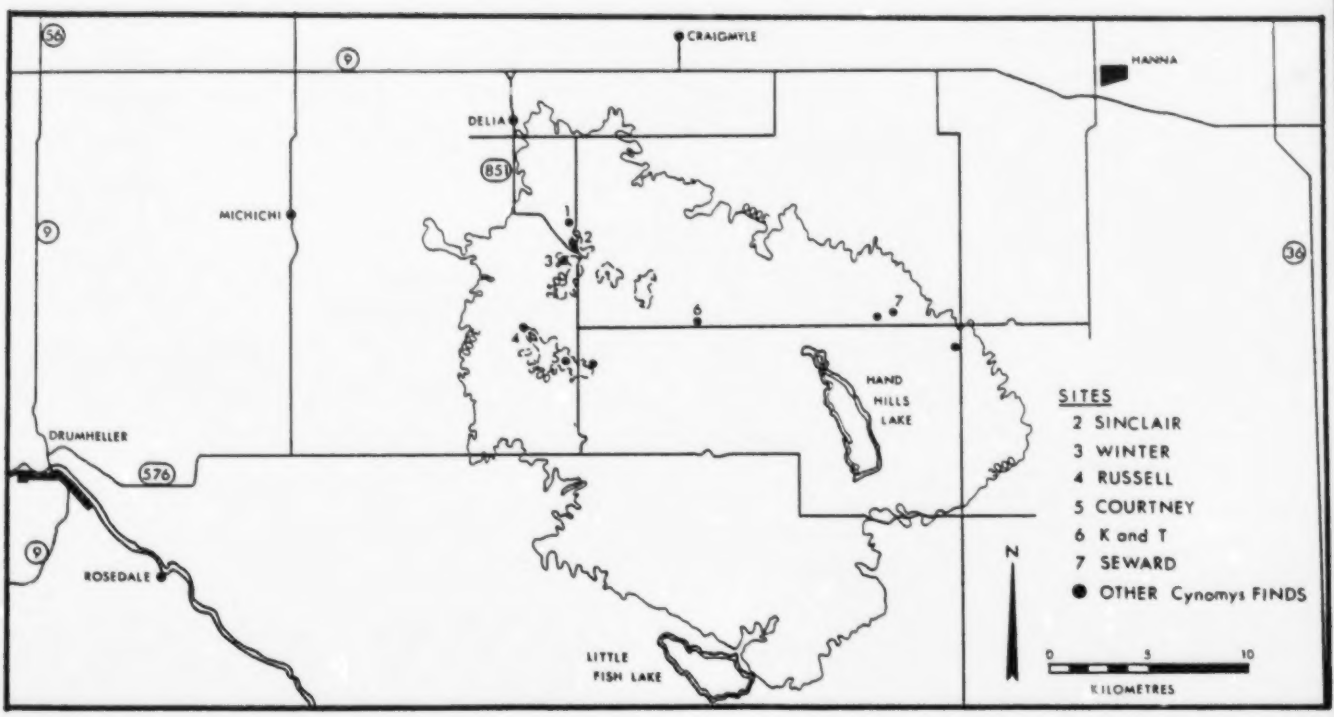
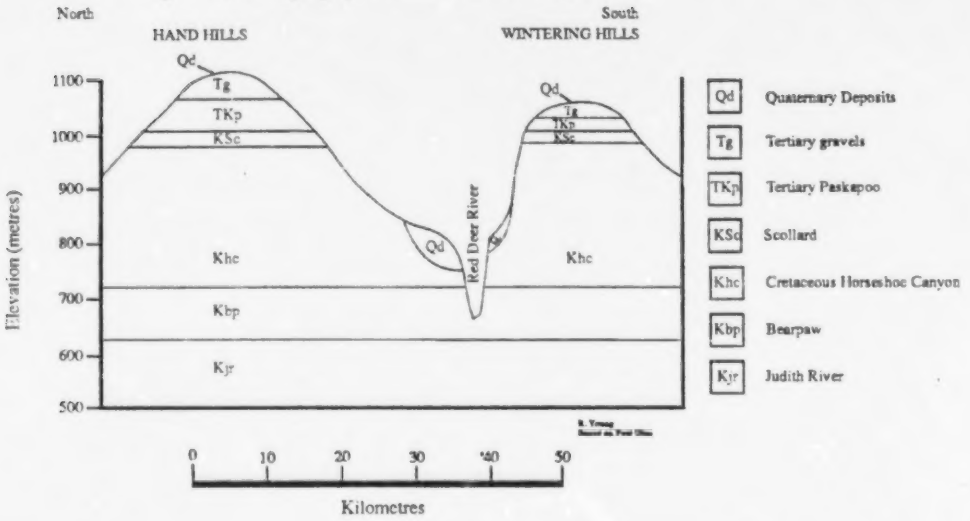


Figure 2; Stratigraphy of Hand Hills and area



STOP 2 : Farther up the hill, again on the **right**, is a section that reveals **Paskapoo Fm** of late Paleocene age. Dr. R.C. Fox, of the University of Alberta, has been examining a Tiffanian faunule from this site. At a gross level it contains Insectivores, Primates, Multituberculates, and Condylarths; details are unavailable at this time.

Higher in this section Miocene and Pleistocene deposits are present. At other places in the Hills a correlative gravel has been referred to as the **Hand Hills conglomerate** (Russell 1958). Here, however, at the **Sinclair Site**, Storer (1976) referred to the sands and gravels *and* the glacial drift as the **Hand Hills Fm**. (This is not a formal designation; apparently, "Formation" and "Conglomerate" have been used interchangeably.) On the flats above is Storer's locality where, in the early 1970s, he reported the **Miocene / Pleistocene** fauna (Table 1A and 1B), including the first prairie dog specimen from the Hand Hills. Numerous other recoveries of *Cynomys* have been made since.

Table 1A and 1B: Vertebrate species from the Sinclair Site; a Barstovian or Clarendonian (middle Miocene) locality with capping fossiliferous sediments of Rancholabrean (late Quaternary) age (after Storer 1976)

Table 1A: Mio-Pliocene fauna of the Hand Hills Formation.

Taxon	Known temporal range
Merychippus sp.	Hemingfordian to Clarendonian
Hipparion sp.	Barstovian to Blancan
Camelidae, gen. et sp. indet.	-
Sciurinae, gen. et sp. indet.	-
Copemys sp.	Barstovian to Hemphillian
Pseudadjidaumo cf. *russelli*	Late Barstovian

Figure 3; The Winter Site in the summer of 1986

Table 1B: Pleistocene fauna of the Hand Hills Formation.

Taxon	Known temporal range
Elephantidae, gen. et sp. indet.	Irvingtonian to Holocene
Equus cf. *conversidens*	Irvingtonian to Holocene
Spermophilus cf. *richardsonii*	Irvingtonian to Present
Microtus cf. *pennsylvanicus*	Irvingtonian to Present
Geomys sp.	Blancan to Present
Leporidae, gen. et sp. indet.	-

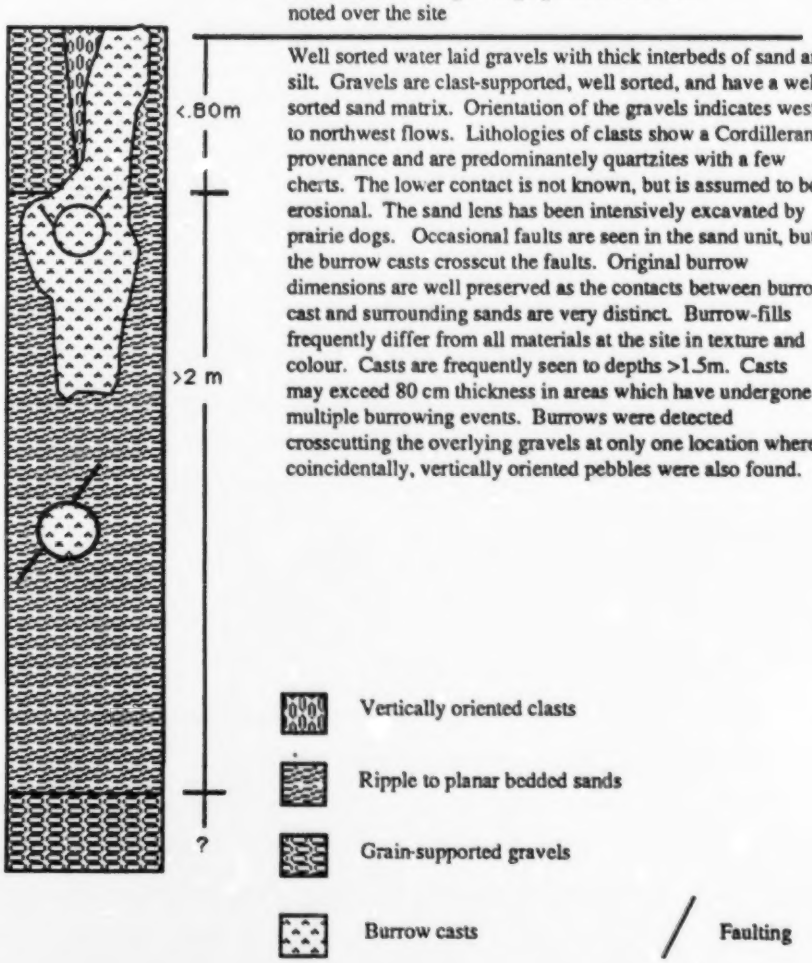
STOP 3 : The **Winter Site** - our major prairie dog excavation - was in a gravel pit that has been backsloped and reseeded (so there is nothing to see). An area south of the Winter Site may be open at the time of the field trip. Briefly, an area of 75 m^2 was excavated to an average depth of about 1.5 m revealing many tens of metres of earth-filled tunnels (Figure 3). These were "defined", surveyed in three dimensions, and mapped. Burrow fill was hand-picked or water-sieved to remove the bones and teeth, and "soil" samples taken for colour and granulometry analyses.

The burrows were intruded into a 2-m thick unit of well sorted, laminated-to-very-thinly bedded sands and silts which were encased in very thin-to-thinly bedded, pebble-to-cobble sized, well rounded gravels (Figure 4). The sands and gravels are thought to be Miocene, correlative with other stratigraphically equivalent fossiliferous units in the Hand Hills. Locally, the clasts overlying the sand unit were vertically oriented. Notably, at the only location where a burrow was detected breaching the overlying gravel, vertically oriented clasts were very common. If the prairie dogs were exploiting the weaker, vertically oriented gravels in order to reach the underlying sand units, then this provides a means of relative dating for the reorientation of the gravels and, thus, the conditions that would have caused it. The prairie dogs would have to have breached the overlying

gravels to gain access to the sandy unit. Prairie dogs are capable of burrowing even in moderately cemented sediments; cobbles are an inconvenience, not a barrier.

The overlying, younger sediments were removed by either glacial or man-induced processes; therefore, the geological context of the Pleistocene burrows could not be immediately assessed. Later analysis showed that material from near the mouth of the burrows was the source of much of the fill. But some of the fills were found to differ from the surrounding sediments in texture and colour. An extended programme of sampling and analysis of units capping the Hand Hills at other sites strongly suggested that the lower of two glacially deposited units was the source of the anomalous fills (Young and Burns in prep.). In 1987 gravel quarrying west of the Winter site revealed a till. Textural and colour affinities strongly suggested that a unit equivalent to this till was the source of the anomalous fills. Later in the season, burrow casts containing diagnostic prairie dog teeth and bones were found in this unit. Note that no Canadian Shield clasts have been found in this unit, even though it is highly unlikely to have Cordilleran origins. A high degree of local dilution probably caused the lack of Shield clasts. Shield clasts are usually indicative of Laurentide, continental, glacial

Figure 4;
General stratigraphy of Winter Site


A discontinuous lag of large granitic clasts was noted over the site
<.80m
Well sorted water laid gravels with thick interbeds of sand and silt. Gravels are clast-supported, well sorted, and have a well sorted sand matrix. Orientation of the gravels indicates west to northwest flows. Lithologies of clasts show a Cordilleran provenance and are predominantely quartzites with a few cherts. The lower contact is not known, but is assumed to be erosional. The sand lens has been intensively excavated by prairie dogs. Occasional faults are seen in the sand unit, but the burrow casts crosscut the faults. Original burrow dimensions are well preserved as the contacts between burrow cast and surrounding sands are very distinct. Burrow-fills frequently differ from all materials at the site in texture and colour. Casts are frequently seen to depths >1.5m. Casts may exceed 80 cm thickness in areas which have undergone multiple burrowing events. Burrows were detected crosscutting the overlying gravels at only one location where, coincidentally, vertically oriented pebbles were also found.
>2 m
?
Vertically oriented clasts
Ripple to planar bedded sands
Grain-supported gravels
Burrow casts
Faulting

deposits, and are common over the top of the Hand and Wintering hills. The two glacial units are therefore discernible by the presence or absence of both prairie dog fossils and Shield clasts. The ^{14}C date of **22,200 ± 320 y B.P.** places the occupation of the site in the latest part of the **Middle Wisconsinan Interstadial** or at the beginning of the **Late Wisconsinan Stadial.** The dated sample was taken from a burrow fill which was one of a number of burrow fills that were darker than the rest and cross-cut them. The cross-cutting relationships indicate that these burrows were the youngest at the Winter Site. The darker fills were likely caused by fill material stained by a deeper soil horizon formed in response to moister conditions before the onset of late Wisconsinan glaciation. The development of the soil horizon was roughly contemporaneous with changes in the climate which ultimately caused the extirpation of the prairie dog colony.

Paleontologically, the site yielded over 3000 bones and teeth of 10 vertebrate species (Table 2), but prairie dogs were predominant. The clearly white-tailed species of "dog" is new to science (Burns and McGillivray in prep.). The site constitutes the only major excavation of fossil prairie dog burrows in North America and the largest collection of fossil *Cynomys* remains from a single locality. The identified commensals and other co-habitors are not zoogeographically unusual when compared to lists of same for modern white-tailed prairie dog colonies in Wyoming (Campbell and Clark 1981).

Table 2: Vertebrate species from the burrows of the Winter Site, a late Middle Wisconsinan prairie dog colony.

Lagomorpha
Lepus cf. *L. townsendii* (cf. White-tailed Jackrabbit)
Rodentia
Peromyscus maniculatus (Deer mouse)
Lemmiscus curtatus (Sagebrush Vole)
Thomomys talpoides (Northern Pocket Gopher)
Spermophilus richardsonii (Richardson's Ground Squirrel)
S. tridecemlineatus (Thirteen-lined Ground Squirrel)
Cynomys (Leucocrossuromys) sp. ("White-tailed" Prairie Dog)
Aves
2 unidentified species
Amphibia
?Salamander sp.

STOP 4A : Mother's Mountain and the **Russell Site.** This is the locality where Dr. Loris Russell found a horse astragalus in 1956. (He was looking for Tertiary fossils. As luck would have it, he had gone empty-handed until this, his third and last trip to the Hand Hills.) The bone was found out of context but it *seemed* to have derived from the "Hand Hills Conglomerate." In 1985, JAB's crew from the Provincial Museum of Alberta visited the Russell Site and found *in situ* a tooth of a Miocene rhinoceros, *Teleoceras* sp., thus suggesting a Miocene age also for the horse astragalus which, at best, is a poor diagnostic element in horses.

As noted earlier, many granitic cobbles and boulders dot the surface of the Hills. These erratics are derived from the Precambrian Shield, far to the north and northeast, and indicate glacial transport into the area. A small granitic boulder is located at the pinnacle of Mother's Mountain a few metres south of the Russell Pit.

STOP 4B : A "no-name" site, situated on Mother's Mountain a few hundred metres SE of the Russell Site, contains good examples of large **ice-wedge casts** indicative of **periglacial conditions** at some time in the past. There are products of periglacial congeliturbation, along with the vertically oriented pebbles. In some cases the approximate relative ages of these features can be stated (relative to a Pleistocene glacial event) because of their relationship to fossil burrows.

STOP 5 : The Courtney Pit, located about 2 km SW of the Russell Site, was a bonanza. It has a good show of Pleistocene prairie dog burrows (not as extensive as at the Winter Site) with an AMS radiocarbon date on collagen of **33,460 ± 350 y B.P.** However, the majority of the exposed sediments are Miocene in age and these also produced some revealing Miocene fossils. Teeth and postcranial materials from three or four horse species were among the important finds. The faunal list grows after each visit. With over a hundred specimens to date, there are nearly a dozen taxa represented (see Table 3 and Figure 5). The occurrence of an immature **wolverine** humerus (*Plesiogulo* cf. *P. marshalli*) indicates a biostratigraphic identity to the **Late Hemphillian.** [Radiometric dates in 6 U.S. sites range from **4.7 to 6.6 my B.P.** (Harrison 1981).] The other species exhibit temporal overlap.

Figure 6; generalized stratigraphy of the Courtney Site

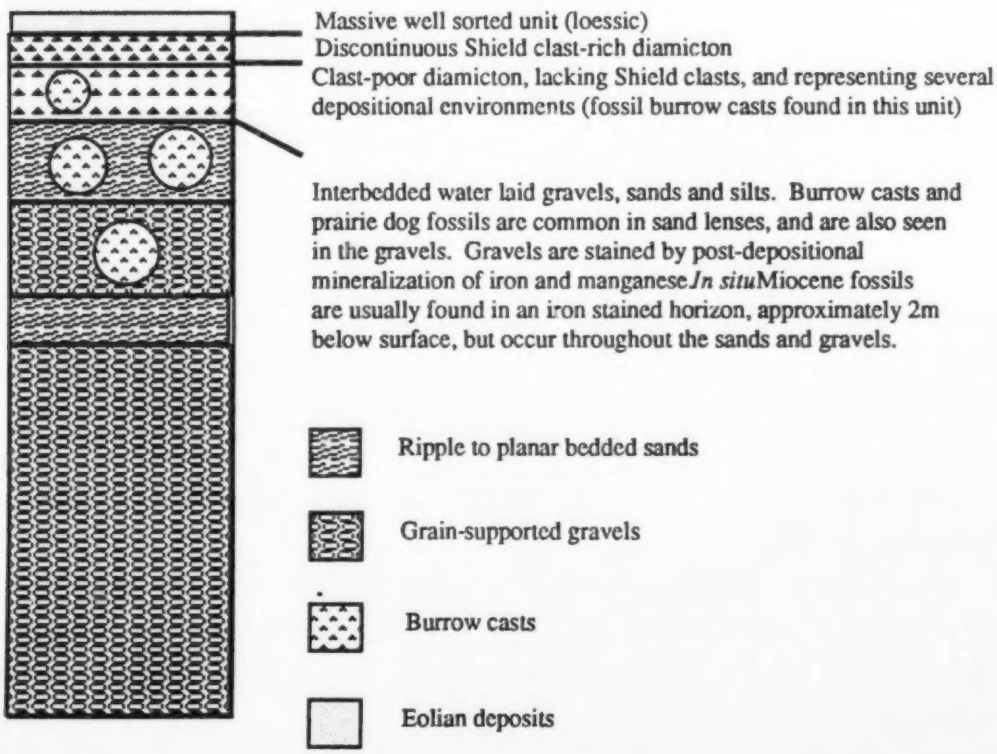

Massive well sorted unit (loessic)
Discontinuous Shield clast-rich diamicton
Clast-poor diamicton, lacking Shield clasts, and representing several depositional environments (fossil burrow casts found in this unit)
Interbedded water laid gravels, sands and silts. Burrow casts and prairie dog fossils are common in sand lenses, and are also seen in the gravels. Gravels are stained by post-depositional mineralization of iron and manganese *In situ* Miocene fossils are usually found in an iron stained horizon, approximately 2m below surface, but occur throughout the sands and gravels.
Ripple to planar bedded sands
Grain-supported gravels
Burrow casts
Eolian deposits

Table 3: Late Hemphillian (latest Miocene) vertebrates from two sites in the Hand Hills near Drumheller, Alberta. (Unpublished identifications by James A. Burns and Michael R. Voorhies)

RUSSELL PIT (Stop 4)

Perissodactyla

Equidae sp. in doubt, large (see Russell 1958)
Teleoceras sp., small rhinoceros

COURTNEY PIT (Stop 5)

Lagomorpha

?*Hypolagus vetus* (Rabbit)

Rodentia

Castoridae sp. (yet unidentified beaver)

Artiodactyla

Neotragocerus sp. (enigmatic antelope-like bovid)
cf. *Megatylopus* (large camel)
Camelidae (yet unidentified camel)

Perissodactyla

Nannippus lenticularis (three-toed horse)
Neohipparion eurystyle (another)
Dinohippus leidyanus (one-toed horse)
Equidae (yet unidentified horse)

Carnivora

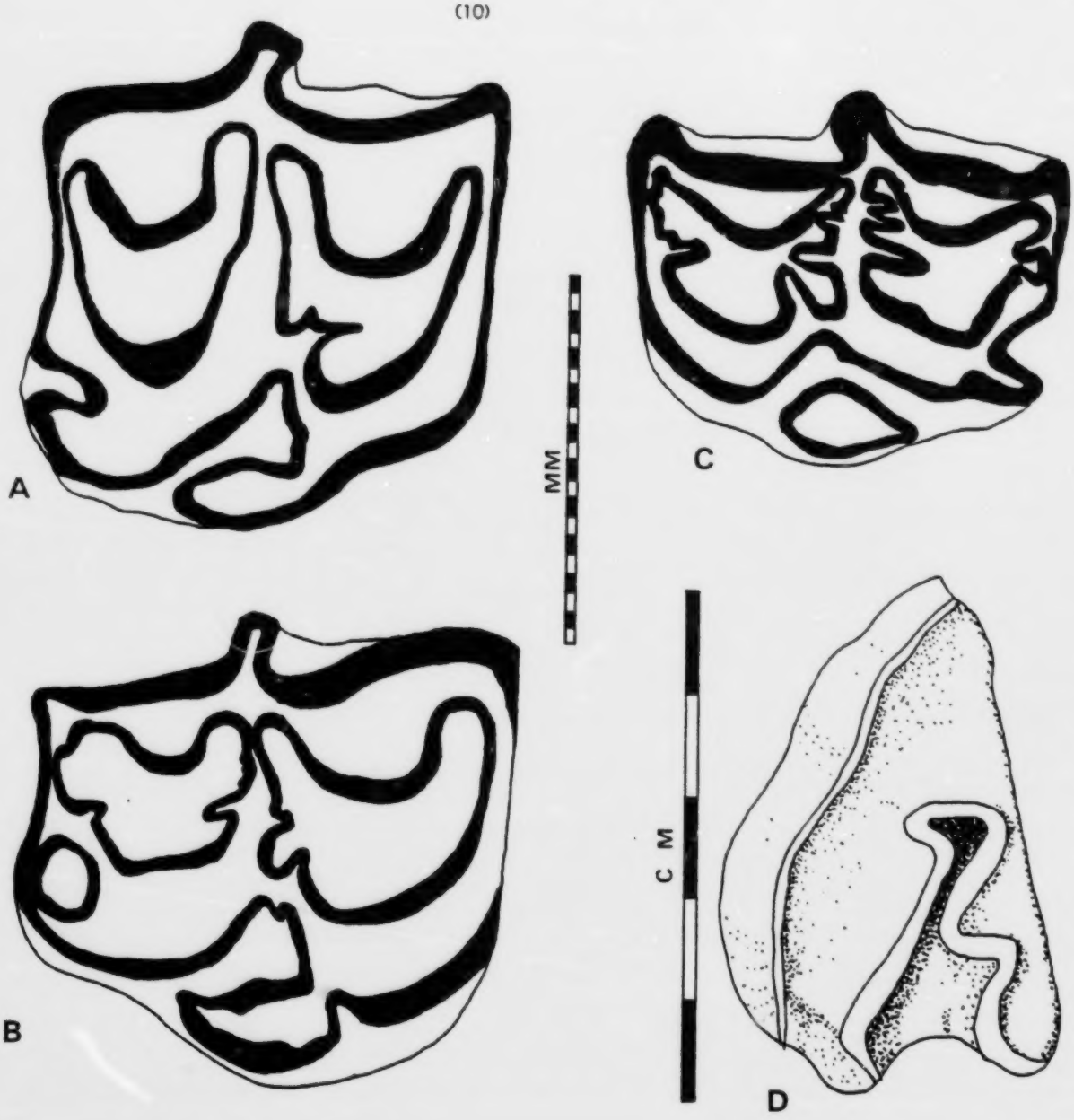
Plesiogulo cf. *P. marshalli* (wolverine)

The general stratigraphy of the site is illustrated in Figure 6:

STOP 6 : The **K & T Site** provides data important for the interpretation of glacial events and sequences in the Hand Hills. Prairie dog bones are present in distinguishable burrows and the burrows present cross-cutting relationships that clarify the two-fold glaciation of the Hills. Controversy over the exact number of glaciations represented in the province continues. The evidence of even two glaciations is hard to find.

We have been examining sites along the western side of the Hills. The Hills consist of two major ridges trending NW to SE separated by a **trough** containing lakes such as the alkaline **Hand Hills Lake**. You will see the lake on the **right** as we travel on to the next stop which is situated on the eastern ridge of the Hills. It is a lake of highly variable depth from year to year. An attempt was made some years ago (Kroker 1979) to extract a core from Little Fish Lake, 9 km SW of Hand Hills Lake, to obtain fossil pollen but only an incomplete core was obtained because of a very solid caliche at shallow depth.

STOP 7 : The "type" section which illustrates the late glacial history of the Hand Hills occurs here at the **Seward Site.** Not only are there burrows with large enough bone samples for AMS dating (assays are pending), but also a record of the **most complete sequence of late Miocene and Pleistocene events in the Hills,** leaving no doubt about the **two-fold glaciation.** Finally, then we have some proof of the existence of the pre-Late Wisconsinan buried "soil" predicted from the nature of the burrow fills at the Winter Site. Figure 7 illustrates the stratigraphic picture at Seward.



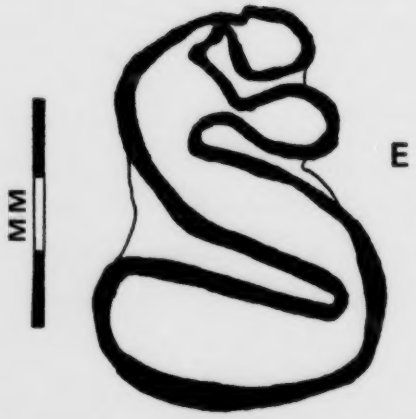


Figure 5. Occlusal patterns of some Late Hemphillian teeth, Hand Hills.

A, B? *Dinohippus leidyanus*

C *Nannippus lenticularis*

D *Teleoceras* sp.

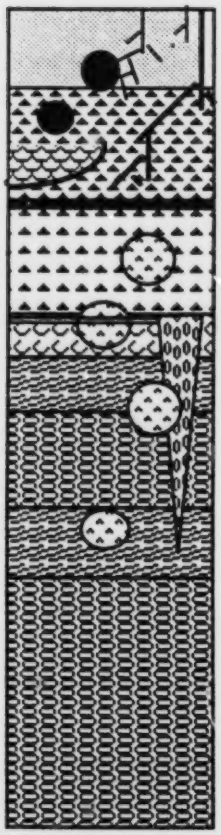
E Castoridae sp.

If time were to permit, the trip would continue on to the south side of the Red Deer River, just south of the hamlet of East Coulee. Here in the **Wintering Hills** there are three contiguous sites, at elevations about 60 m (200 ft) lower than the western Hand Hills sites that contain prairie dog burrows and bones. An AMS ^{14}C date from the **Schowalter Site** of **28,000 ± 250 y B.P.** correlates these occurrences with those in the Hand Hills. The separation of the two upland remnants no doubt occurred prior to the Pleistocene and clearly there was no barrier to the radiation of prairie dog stock across the intervening lowland. The area at the time was probably **cooler and drier than today**, admirably suited to the spread of these rodents. Towards the end of the mid-Wisconsinan interstadial, conditions must have become moister, as witnessed by the late soil development. It is not clear why there are no prairie dogs in Alberta today.

SUMMARY

Lack of diagnostic fossil material and good sedimentologic marker horizons has hampered efforts to differentiate stratigraphic units on the top of the Hand Hills. The in *situ discovery* of *Teleoceras* sp. and *Plesiogulo marshalli* by JAB, in the Russell and Courtney gravel pits, respectively, has conclusively shown that the gravels are of Hemphillian age. A study of the taphonomy of JAB's fossil prairie

Figure 7; General stratigraphy of the Seward Site



Massive well-sorted medium to fine grained sands. Burrow casts containing modern *Spermophilus richardsonii* bones are common

Interbeds of Shield clast-rich diamict and water laid sands and grits.

Continuous weathered horizon, conformable with underlying diamict

Clast-poor (Shield clasts absent) diamict. Fine laminae, deformed downward by clasts, are fairly common. Limited quantities of fossil prairie dog bones have been found in this unit.

Interbeds of clast-supported gravels and sands. Soft deformation structures (ball and pillow) are common where sands are at the upper contact. Vertically oriented pebbles occur in wedges to approx. 1.8m. Fossiliferous burrow casts crosscut above structures. Burrow casts coincide with vertical pebbles in thicker gravels until lower sand lenses are reached.

Vertically oriented clasts

Eolian deposits

Ripple to planar bedded sands

Grain-supported gravels

Burrow casts

Recent burrow casts

dog sites has allowed RRY to identify two separate glacially deposited units.

With the information gained over the last four years, we may now propose the following summary of events in the Hand Hills and area. The gravels were deposited during the last major uplift event of the Rocky Mountains, and are contemporaneous with the Flaxville Plain. Subsequent erosion, primarily fluvial, left the Hand Hills as a member of a series of relict upland areas. A period of intense periglacial activity preceeded evidence of the earliest glaciation in this area. An early continental Laurentide glaciation submerged the Hand Hills, leaving a distinctive, Shield clast-poor till which truncates periglacial structures at several sites. Prairie dogs then invaded the area, burrowing into the old till and the underlying Miocene units. Cooler, moister conditions before onset of the latest glaciation (<22,200 y BP) allowed the formation of a thicker organically stained A horizon. Cooler conditions caused limited periglacial activity immediately before onset of the latest glaciation. The latest ice sheet deposited a discontinuous till unit which is rich in clasts of Canadian Shield provenance.

ACKNOWLEDGEMENTS

For information pertaining to the local, pre-Quaternary, stratigraphy and paleontology we thank Drs. David Eberth, Tyrrell Museum of Paleontology, and R.C. Fox, University of Alberta, Edmonton. For assistance in identifying Miocene fossils from the Courtney and Russell sites we gratefully acknowledge Dr. M.R. Voorhies, University of Nebraska State Museum, Lincoln, NE. For their perceptive comments and their much needed encouragement we heap thanks on Drs. Bruce Rains, University of Alberta; Fred Bachhuber, University of Nevada, Las Vegas; and David Eberth, Tyrrell Museum. RRY would like to thank JAB, the Provincial Museum of Alberta, and the Royal Canadian Geographical Society for their support. Also, we greatly appreciate the input of Paul Glen, an M.Sc candidate in geology at the University of Calgary.

Local landowners have been especially kind in allowing us to proceed with excavations on their properties and the field trip; we thank in particular Doug Winter, Fred Courtney, Ray Sieppert, Al Seward, and Penny and Melvin Pfahl. The Provincial Museum of Alberta crews who burnt their buns in the sun for the cause from 1984-88 were the *sine qua non* and are herein immortalized: Dale MacInnes, Gopal Dongol, Heather Wilson, Dale Harrison, Myron Pilip, and . . . . .need we include ourselves? One last person who deserves our collective thanks and sincere admiration for his abilities in the field of paleontology - who wanted to be a paleontologist from the time he could pronounce the word, and has found the proverbial needle in the haystack many times over - stand up, please, Tim Schowalter.

LITERATURE CITED

ALLAN, J.T. and J.O.P SANDERSON. 1945. Geology of Red Deer and Rosebud sheets, Alberta. Research Council of Alberta, Report No. 13. 109 pp.

BRYAN, R.B., I.A. CAMPBELL, and A. YAIR, 1987. Postglacial geomorphic development of the Dinosaur Provincial Park Badlands, Alberta. *Canadian Journal of Earth Sciences* 24(1):135-146

CAMPBELL, T.M., III and T.W. CLARK. 1981. Colony characteristics and vertebrate associates of white-tailed and black-tailed prairie dogs in Wyoming. *The American Midland Naturalist* 105(2):269-276.

DYKE, A.S. and V.K. PREST. 1987. Late Wisconsinan and Holocene history of the Laurentide ice sheet. *Géographie physique et Quaternaire* 41(2):237-263.

HARRISON, J.A. 1981. A review of the extinct wolverine, *Plesiogulo* (Carnivora: Mustelidae), from North America. *Smithsonian Contributions to Paleobiology* 46:1-27.

HECTOR, J. 1861. On the geology of the country between Lake Superior and the Pacific Ocean. *Quarterly Journal of the Geological Society of London* 17.

KROKER, S. 1979. Late Holocene paleoecology of the Hand Hills region of Alberta: implications for archaeological research. M.A. Thesis, University of Manitoba, Winnipeg.

McCONNELL, R.G. 1885. Report on the Cypress Hills, Wood Mountain, and adjacent country. *Geological Survey of Canada, Annual Report* 1, Pt. C:1-78.

RUSSELL, L.S. 1958. A horse astragalus from the Hand Hills Conglomerate, Alberta. *National Museums of Canada, Natural History Papers* 1:1-3.

STALKER, A. MacS. 1973. Surficial geology of the Drumheller area, Alberta. *Geological Survey of Canada Memoir* 370: 1-122.

STORER, J.E. 1972. Mammals of the Hand Hills Formation of southern Alberta: preliminary faunal list. *Blue Jay* 30(2):119-120.

_____1975. Pleistocene prairie dog in south-central Alberta. *Blue Jay* 33(4):247.

_____1976. Mammals of the Hand Hills Formation, southern Alberta. Pp. 186-209 *in* C.S. Churcher (ed.), *Athlon: essays on palaeontology in honour of Loris Shano Russell*. Royal Ontario Museum, Life Sciences Miscellaneous Contributions. 286pp.

_____1978. Tertiary sands and gravels in Saskatchewan and Alberta: correlation of mammalian faunas. Pp. 595-602 in C.R. Stelck and B.D.E. Chatterton (eds.), Western and Arctic Canadian biostratigraphy. *Geological Association of Canada Special Paper* 18.

TYRRELL, J.B. 1887. Report on a part of northern Alberta and portions of adjacent districts of Assiniboia and Saskatchewan, *Geol. Nat. Hist. Surv. Can., Ann. Rept., new series*, 2:1E-176E

WARREN, P.S. 1939. The Flaxville Plain in Alberta. *Transactions of the Royal Canadian Institute* 22(2):341-349.